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(54) Abstract Title
Apparatus and method for rearing and collection of aquatic organisms

(57) The apparatus comprises a vessel 1 with means to maintain a predetermined level of water in the vessel, and a number of habitats below the water level each capable of receiving an organism. The habitats may be tubular structures 8 of metal or synthetic plastics material, and in a preferred embodiment the habitats 9 are formed between two substantially parallel plates by a number of dividing walls extending between the parallel plates. An installation (figs 2 and 3) comprising a number of vessels arranged in a vertical stack with a cascading flow of water passing down through the stack of vessels is also described. The apparatus may be used for the culture of king ragworms.

FIG. 1

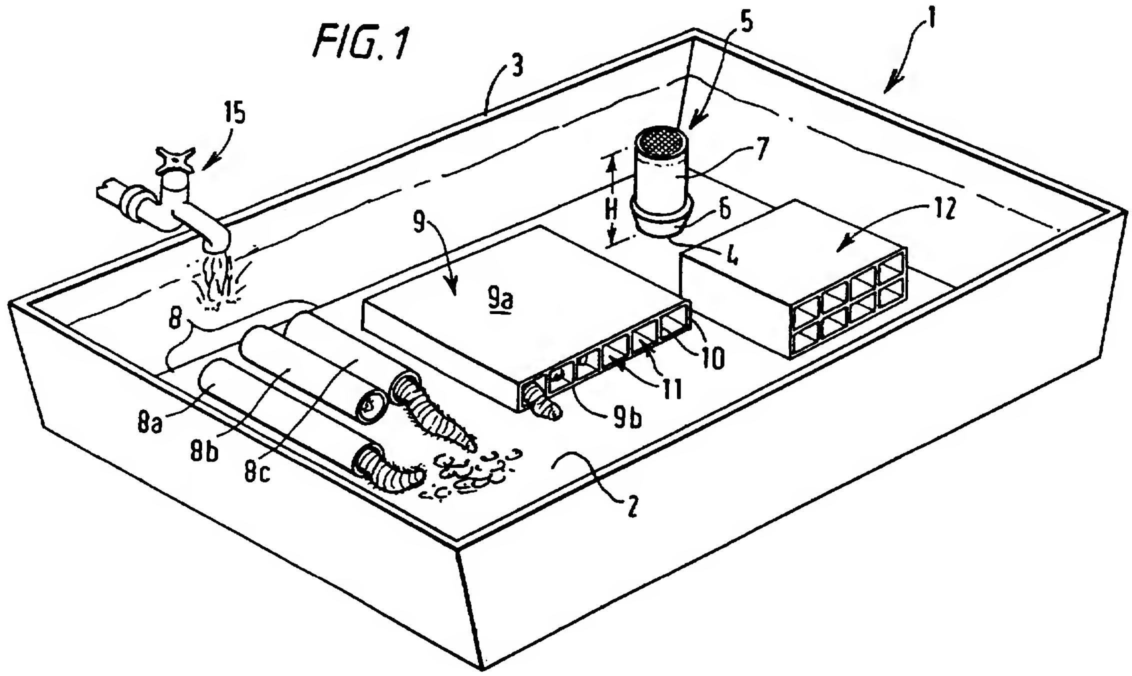

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FIG. 1

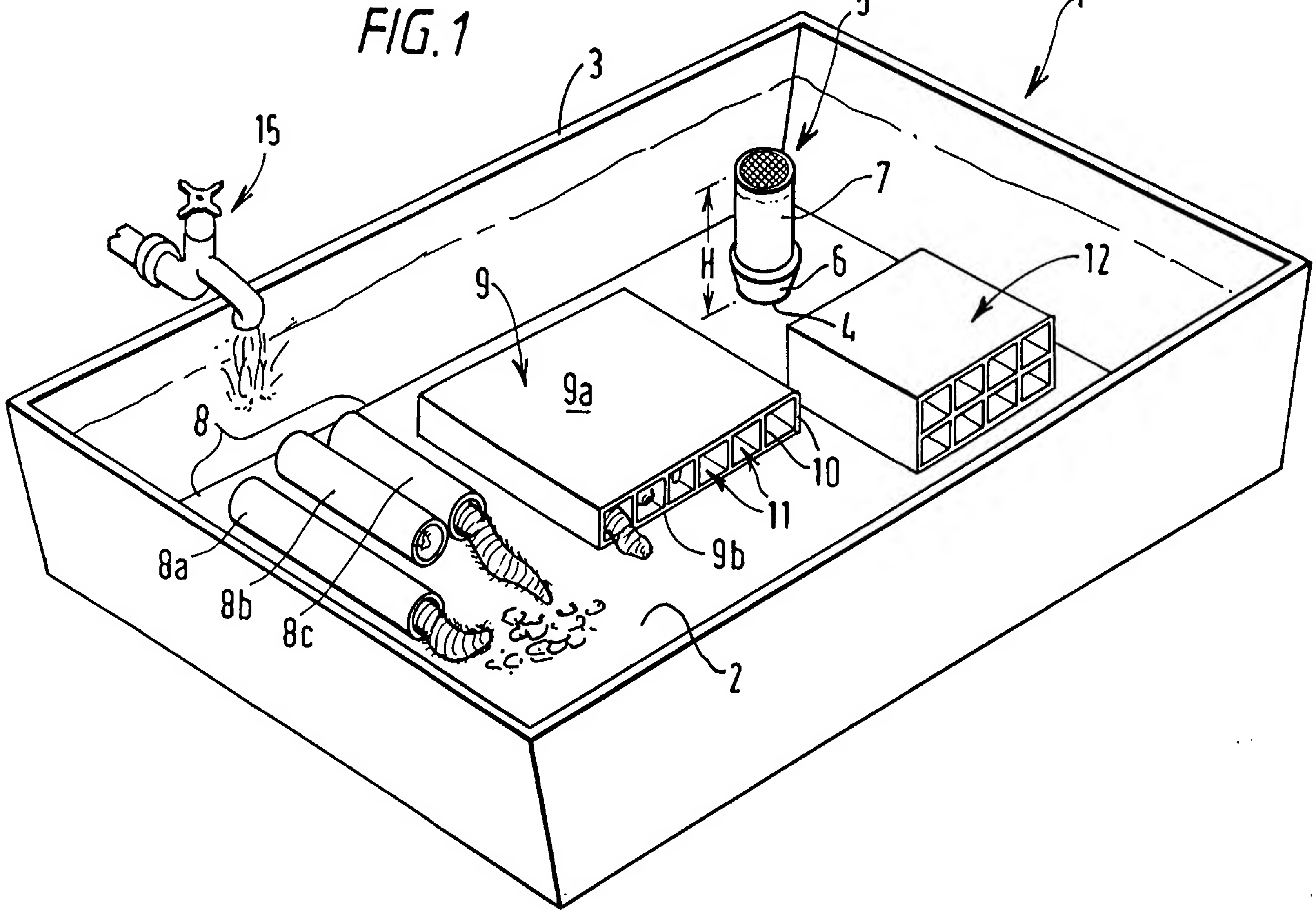


FIG. 2

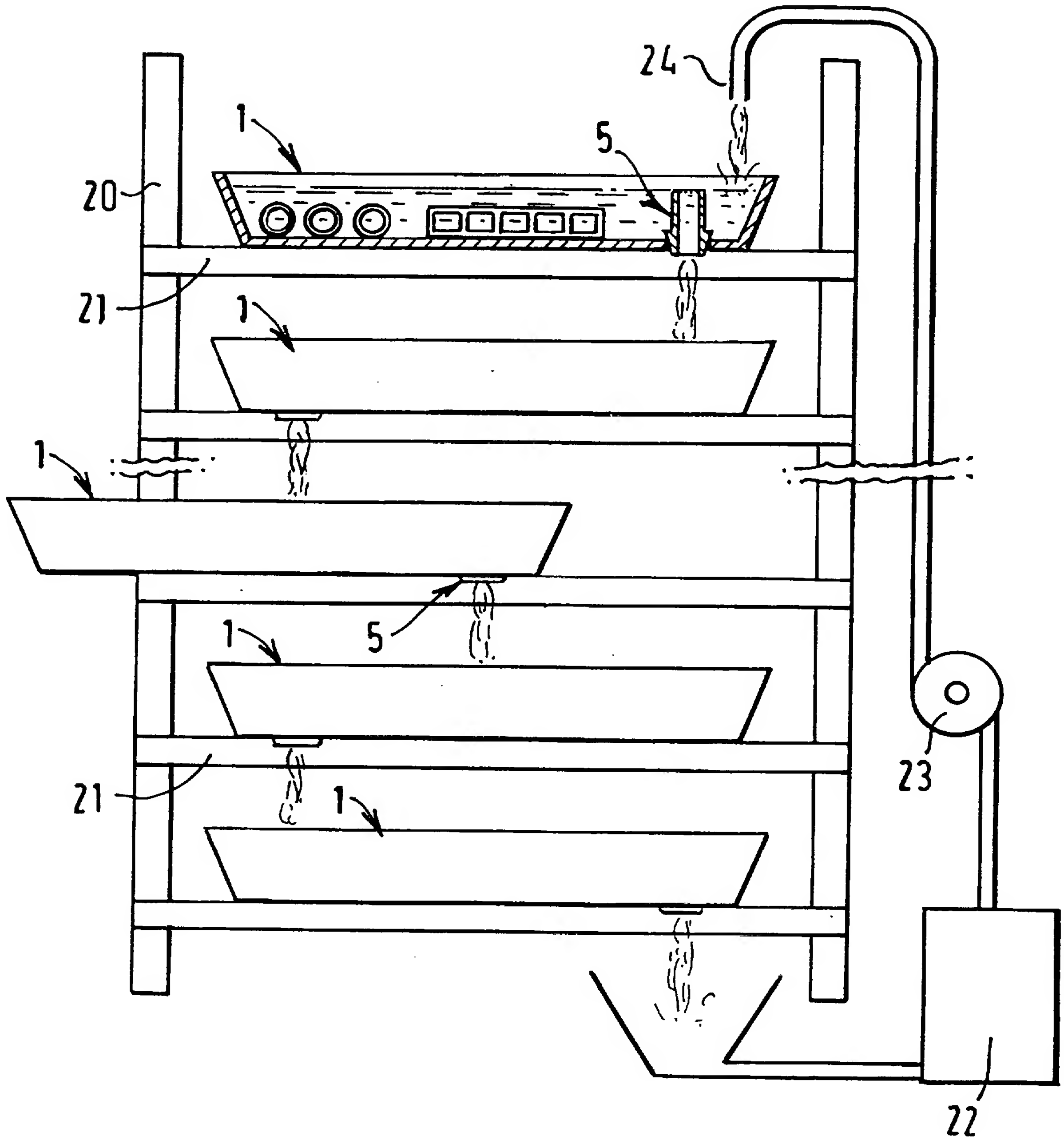
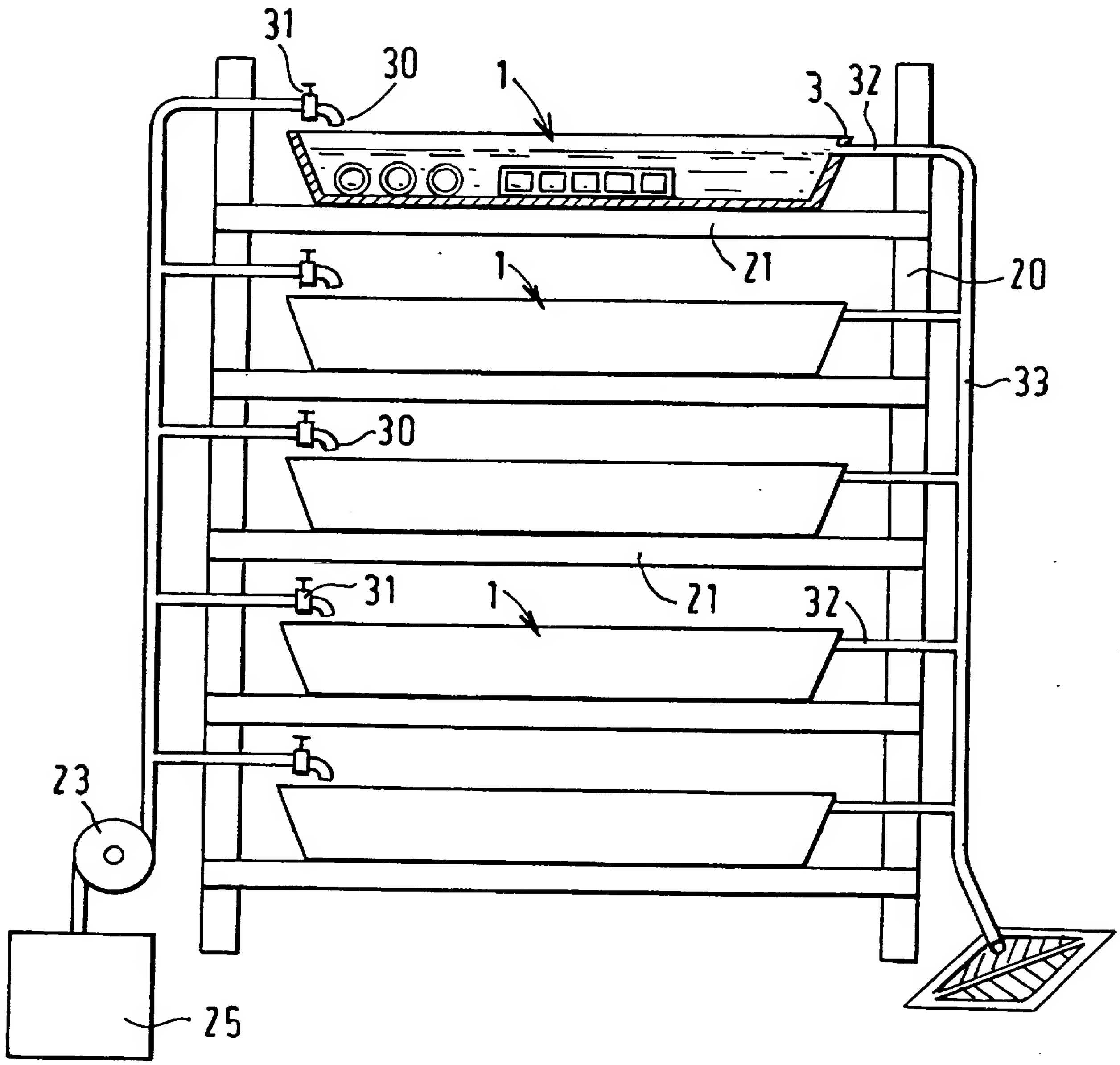


FIG.3



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Apparatus and method for rearing and collection of aquatic organisms

The present invention relates to the culture or farming of aquatic organisms, and particularly concerns the provision of apparatus and methods for rearing and collecting ragworms or similar aquatic organisms.

King Ragworms (*Nereis virens*) are marine worms which form burrows in marine sediments for refuge. The worms occupy the burrows for protection against predators, but may emerge from the burrows in search of food. When plentiful food supplies are available in the water, the worms may remain in their burrows with the head end of each worm protruding from the burrow to capture particulate foodstuffs which are carried past the burrow on ocean currents or tidal flows.

Once they have grown to approximately 12 to 15 cm in length, ragworms, especially king ragworms (Nereis virens), are sought-after as bait by marine anglers. Anglers have traditionally collected ragworms by digging them out of the natural marine sediments where they burrow. At the time of digging, the anglers select those ragworms which are sufficiently large to be used as bait, leaving the juvenile ragworms in the sediment to develop further. The traditional collection method is labour-

intensive, and has an uncertain return as bait diggers must cover a large area of exposed mud flats at low tide, in order to gather comparatively small quantities of ragworms, which are well-dispersed in the wild. Nevertheless, bait digging has a detrimental impact on the environment.

In order to gather ragworms in larger quantities from the wild, there has recently been developed a commercial technique wherein mud flats are trawled or dragged to collect ragworms from the disturbed sediment. Although this yields larger quantities of ragworms per unit labour cost, the selection process which accompanies traditional bait-digging methods is absent and this results in juvenile ragworms being collected along with the adult specimens. The ragworm colonies are thus seriously depleted, and this has a negative ecological impact.

Farming techniques have been developed wherein ragworms are reared in artificial outdoor lagoons in which sea water or salt water overlies a bed of sand or silt. Ragworms are introduced into the lagoon and distribute themselves over and through the sediments in higher concentrations than are found in the wild. Since the population in each lagoon can be carefully controlled so that all the ragworms are of the same age and size, collection of the ragworms is effected by digging the

sediment when the ragworms have reached the appropriate age for collection and marketing as bait. The collection method is the same as the traditional method of gathering the worms from the wild, i.e. the worms have to be removed from the sediment. In such artificial lagoons, the concentration of ragworms per unit area is considerably higher than that found in the wild, increasing the number of worms which a digger can collect per hour. However, an upper limit of population density exists due to the randomness of the burrowing of the worms. When neighbouring burrows intersect, the worms may move on and form new burrows to escape the disturbance. If a large proportion of the worms in a colony are being continually disturbed, the worm population may fail to thrive.

While these farming techniques are more efficient than the traditional gathering of worms from the wild, in that more worms can be collected from lagoons of increased population density, disadvantages of the farming techniques are that large areas of land are required for the formation of lagoons, and that the gathering process is still labour-intensive as the worms must be removed from the sediment. Although the distribution of worms in the sediment is more dense than is found in the wild, the distribution is random and there is no certainty that all the ragworms have been removed from a lagoon on

harvesting. Furthermore, the lagoons are exposed to the weather, and therefore may experience natural variations of temperature and day length throughout the year.

The present invention seeks to provide methods and apparatus for the culture and collection of ragworms or similar aquatic organisms, wherein large numbers of organisms can be reared in a small area of ground. A further objective of the invention is to provide apparatus and an installation constituting a rearing environment in which the organisms may be conveniently reared at high density, and from which the organisms can be easily collected, and the complete collection of the organisms can be easily verified. Another objective of the invention is to provide a method and apparatus for rearing aquatic organisms in which the rearing conditions may be completely controlled in order to take full advantage of any behavioural responses of the organism to external stimuli such as temperature, day length or the like.

Although the present invention will be described with reference to ragworms, it is to be understood that the technique may be applicable to any kind of marine or freshwater worm or other organism which forms a burrow for refuge. Examples of other organisms to which the present method and apparatus may be applicable are

arthropoda, such as shrimps, prawns and crayfish; mollusca such as octopus; and annelida such as ragworms. The apparatus is suitable for species which feed on particles in the water, rather than those types of organism which burrow through sediment to extract nutrients from ingested sediment.

According to a first aspect of the present invention, an apparatus for rearing aquatic organisms comprises a vessel adapted to contain water up to a predetermined level, the vessel being provided below the said level with a number of preformed habitats to receive the organisms. Each habitat has at least one entry and exit opening, and a living chamber. The shape of the living chamber is preferably similar to the shape of the organism with which the apparatus is to be used. The shape of the living chamber is preferably such that the cross-section of the living chamber does not exceed the dimensions of the entry and exit opening, to provide for easy removal of the organism from the living chamber by avoiding any inwardly-facing surfaces adjacent the entry and exit opening. The internal surfaces of the habitat are preferably smooth, to prevent the organism from gripping the surface.

In a preferred embodiment of the apparatus intended for rearing ragworms, the vessel is an open-topped tray

having an exit opening to define the said level, and the preformed habitats are generally tubular in configuration, with two open ends. Advantageously, the tubular habitats are formed by a pair of spaced parallel plates between which extend a number of parallel dividing walls. In an alternative embodiment, the tubular habitats may be sections of tubular materials such as metal tubes or plastics or rubber hose. The tubular habitats are preferably transparent or translucent, to enable the presence of organisms therein to be visually detectable. The interior walls of the tubular habitats are preferably smooth, to assist in the removal of organisms therefrom. The tubular habitats may be open at both ends, or may have one end closed. The cross-sectional shape of the tubular habitats may be circular, rectangular, or polygonal.

A second aspect of the invention provides an installation for rearing aquatic organisms, comprising a plurality of vessels arranged one above the other in a supporting structure, each of the vessels having a drain opening for defining a water level within the vessel and having a number of preformed habitats within the vessel below the said water level. In a preferred embodiment of the installation, the drain opening of each vessel discharges water into the next vessel below, and water is provided only to the uppermost vessel from a water supply, the

water cascading down through the vessels with the discharge from the lowermost vessel being discarded. Alternatively, the discharge from the lowermost vessel may be treated and re-circulated to the uppermost vessel. In an alternative embodiment, water may be supplied individually to each vessel and the discharge from each vessel be individually led to drain.

A third aspect of the invention provides a method of collecting an aquatic organism from habitat in a rearing apparatus comprising a vessel having a drain opening for defining the water level within the vessel and having a number of preformed habitats within the vessel below the said water level, and wherein each habitat comprises an entry and exit opening and a living chamber, the method comprising the steps of orienting the habitat so that its entry and exit opening is lowermost, and placing a receptacle beneath the habitat to catch the organism as it falls from the habitat. In an apparatus wherein each habitat is formed with two openings, a flow of water may be introduced into one of the openings to flush the organism out of the other opening for collection in a receptacle.

The installation may be housed within a building, provided with temperature and illumination control.

Embodiments of the present invention will now be described in detail with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of a rearing tray according to the present invention;

Figure 2 is a schematic side elevation, in partial section, of a rearing installation comprising a number of rearing trays;

Figure 3 is a view similar to figure 2, showing an alternative arrangement of the rearing installation;

Referring now to figure 1, a rearing tray 1 comprises a substantially rectangular base 2 surrounded by an upstanding side wall 3. A circular opening 4 is formed in the base, and an upstanding tubular plug 5 sealingly engages the opening 4. The plug 5 comprises a substantially conical lower end 6 to seal the opening 4, and an upstanding tubular section 7. An axial bore penetrates the plug 5. The length of the tubular section 7 is arranged so that, when the plug is in place sealing the opening 4, the upper end of the tubular section 7 is at a height H above the base 2 of the tray 1.

As an alternative to the opening 4 and plug 5, the base

of the tray may be formed with an opening surrounded by an upstanding wall attached to the base, or a sidewall of the tray may have a portion of reduced height to act as a weir formed therein for the water to overflow when the required level is reached. A mesh may be extended over the opening, or the opening may comprises a number of small perforations through which the organisms in the tray may not pass, to prevent the escape of organisms from the tray.

On the base 2 of the tray 1 are arranged a number of tubular habitats. The habitats are preferably removable, but may be fixed to the base of the tray. In the example shown, three types of habitat are illustrated. Indicated generally by reference 8 are a number of individual tubular habitats 8a, 8b and 8c. These individual tubular habitats may be formed from glass, metal or plastics tube. If the tray 1 is to be used to rear a population of substantially identical worms, then a number of tubular habitats 8 of substantially identical dimension is preferably provided. The length and diameter of each habitat is selected to suit the type and size of organism to be reared. Taking ragworms as an example, to rear ragworms from juvenile to adult, suitable tubular habitats have been found to be between 5 and 20 cm in length, and from 5 to 15mm in diameter. For rearing ragworms to a commercially marketable size of about 14

cm in length, the tubular habitats are preferably from 12 to 17 cm in length, and have a cross-sectional area of approximately 1 square cm. The tubular habitats are preferably transparent or translucent, so that by visual inspection of the tray, the presence of ragworms in the habitats can be verified. This makes it a simple matter to monitor or count the ragworms in a tray.

Indicated generally at 9 is an alternative habitat material, comprising upper and lower plates 9a and 9b between which a number of vertical dividing walls 10 extend. The upper and lower plates 9a and 9b and the dividing walls 10 define a plurality of adjoining open-ended tubular habitats 11 of rectangular cross-section. The adjoining habitats may be formed from transparent or translucent plastics material such as polycarbonate, the material being commercially available as a roofing material for greenhouses and the like. The tubular habitats may be cut from sheets of this roofing material, to provide habitats of the required length. In the embodiment illustrated, the tubular habitats are 10mm square in cross-section, and have a length of 15 cm.

In an alternative embodiment, the habitats may be formed by a sheet of material having a number of parallel sidewalls depending therefrom, the free edges of the sidewalls resting on the base of the tray. In this

embodiment, the sheet forms the top of each habitat and each pair of adjacent sidewalls forms the sides of a habitat, and the base of the tray forms the base of each habitat. In a further alternative, a corrugated sheet placed on the base of the tray may define a plurality of habitats, between the corrugated sheet and the base of the tray. A flat sheet may be placed over the corrugated sheet to define a further series of habitats between the corrugated sheet and the flat sheet.

The habitats illustrated are of circular and rectangular cross-section, respectively. It is foreseen that the cross-sectional shape of the tubular habitats may be any convenient shape, such as elliptical, polygonal, square, triangular or trapezoidal. In embodiments where the habitats are constructed from opaque material, a small opening may be formed in the side of each habitat so that the presence of an organism in the habitat may be visually verified. Alternatively, a transparent window may be provided in the habitat to permit such visual inspection.

An optimum population density within the tray 1 is achieved by arranging the habitats in parallel rows, with spacing between the rows to allow access to the ends of the habitats 11. In an easily manageable installation, the trays are approximately 40mm high, 45cm in width and

100cm in length, and two longitudinally extending rows of habitats are arranged in each tray. Preferably, the individual habitats are approximately 10mm high, 10mm wide and 15cm in length, and are spaced apart by an aisle of approximately 5cm in width. The tubular section 7 of the plug 5 is preferably arranged such that the depth of water within the tray is approximately 20mm.

A further alternative habitat material is shown at 12. This material is similar to the habitat material 9, but comprises three parallel plates separated by dividing walls to form a "two-storey" structure some 22mm high, with two layers of tubular habitats of square or rectangular cross-section. Whether this habitat material is used, the tubular section 7 of the plug 5 is arranged to provide a slightly greater depth of water, so that the upper layer of habitats is covered by approximately 5mm of water.

All of the habitat structures have a vertical extent less than the height H of the upper end of the tubular section 7 of the plug 5. In use, the tray 1 is supplied from a supply tube 15 with fresh or salt water, or sea water, depending on the organism being reared. The tray fills to the level of the upper end of the tubular section 7, and thereafter water overflows and escapes down through the axial bore of the plug. The upper end of the bore

is preferably provided with a filter mesh, to prevent the worms from escaping. The tray 1 may optionally be provided with a lid or cover to prevent worms from escaping over the side walls 3.

Figure 2 shows schematically a rearing installation comprising a number of trays 1 supported in a frame 20. The trays 1 are preferably removable from the frame, and in the embodiment shown the trays 1 are supported on runners 21 to allow the trays to be slid out of the frame 20 for husbandry and cleaning purposes. The trays are arranged in a vertical stack, so that the water escaping from the uppermost tray through the axial bore in its plug 5 will fall into the next tray below. The installation illustrated in figure 2 has a recirculating water system. From the lowermost tray, outflowing water is collected and passes to a treatment plant 22. The treatment plant 22 may comprise filtration equipment, aeration equipment, salinity regulating equipment and/or temperature control plant such as heaters or coolers. From the treatment plant 22, the water is drawn to a pump 23 which lifts it to a discharge nozzle 24, from whence it returns to the uppermost tray 1.

As an alternative to the recirculating system shown in figure 2, it is foreseen that a "total loss" system may be adopted if a supply of sea or river water, as

appropriate to the organism being reared, is readily available. In such a system, water will be piped from the supply into the uppermost tray 1, to cascade downwardly through the stack of trays for collection and discharge.

In a further alternative arrangement, illustrated in figure 3, a vertical array of trays is supported on runners 21 in a frame 20, as described above in relation to figure 2. In this embodiment, however, water is supplied separately to each tray from a water supply 25 by means of a pump 23. Water is led to each tray individually by means of a supply tube 30, controlled by a valve 31. Water is drawn from each tray 1 via an overflow pipe 32 extending through the side wall 3 of the tray. The overflow pipes 32 lead to a collection manifold 33 which discharges waste water to drain. In the "total loss" system described in figure 3, the flows through the trays 1 are entirely separate, so that no cross-contamination may occur between trays in the event that the organisms in one of the trays become diseased.

The rate of flow of water through the trays need only be sufficient to maintain the necessary water quality in terms of aeration, removal of wastes, etc.. For an installation of 34 trays of the sizes indicated above, a cascading water flow of 5 litres per minute has been

found to be adequate. The flow rate may be in a range of from 0.5 to 10 litres per minute, depending on the size and number of organisms, amount of feeding, water temperature, light level, etc.

The installation is shown in figures 2 and 3 are intended for the rearing of juvenile ragworms to maturity. The ragworms are introduced into the trays when they are some 60 days old, with a length of from 2 to 20 mm. Preferably, the number of ragworms introduced into each tray is equal to the number of available habitats in the tray. There may be some advantage in providing a number of extra habitats in each tray, to provide for mobility of the worms.

The ragworms in each tray may be fed each day by simply placing a quantity of commercially-available animal feed into each tray, preferably adjacent the ends of the habitats. If the ragworms are unable to collect sufficient food while remaining within their respective habitats, they are sufficiently mobile to emerge from the burrows to find feed pellets, using either chemical or visual detection. In the installations of figures 2 and 3, feeding is conveniently affected by sliding each tray in turn out of the frame by a sufficient amount to afford easy access, and sprinkling the feed pellets into the water. Feeding is preferably done on a regular basis,

and may be weekly, daily, or several times a day, provided that at each feeding sufficient nutrients are given for the organisms to thrive until the next feeding.

The flow of water through the cascade may be interrupted during feeding, so as not to lose water from trays which are slid out for treatment. Alternatively, the discharge opening of each tray may be plugged as the tray is slid out for a treatment, and the plug removed when the tray is replaced in the stack.

The installations are preferably based under cover, for example within a building. The light level within the building may be controlled to simulate a day/night cycle, and the relative lengths of apparent day and night within the building amy differ from the outside to provoke seasonal responses in the organisms.

Once the ragworms have grown to a marketable size, the ragworms are easily removed from the trays by simply lifting out the habitats. If the habitats are connected together to form a block, the block may be lifted or tipped so as to place the opening of each habitat lowermost, to eject the ragworms under gravity. When tubular habitats are used which are open at both ends, a water jet may be directed into one of the ends of the habitats to flush out the ragworms through the other end.

The ragworms may be tipped or flushed from the habitats into the rearing tray for collection. Alternatively the habitats may be lifted out of the trays and the ragworms tipped and/or flushed into a catching receptacle, or into a storage container for sale or shipping.

In the embodiments described above, the individual habitats for each ragworm are approximately 10mm in diameter or transverse dimension, and 15cm in length. The precise dimensions of the habitats are not critical, but the habitat must have a volume sufficient to contain a mature organism, in this case a ragworm. The volume of each habitat is preferably between 10 and 20cc. For the rearing of the organisms, the shape and volume of the preformed habitats is arranged to correspond with the shape and size of the respective organism. The entry and exit opening of the habitat must be of sufficient size to permit the removal of the organism at the end of the rearing process. Preferably the habitat has a smooth internal surface and is non-reentrant to avoid the organism "gripping" the surface of the habitats, and most preferably the habitat comprises two openings to facilitate removal of the organism from the habitat by flushing.

Claims

1. An apparatus for rearing aquatic organisms, comprising a vessel adapted to contain water up to a predetermined level, the vessel being provided below the said level with a number of habitats each capable of receiving an organism.

2. An apparatus according to claim 1, wherein the vessel is an open-topped tray having a water exit opening to define the said predetermined level.

3. An apparatus according to claim 1 or claim 2, wherein the habitats are tubular in configuration, and have one end open.

4. An apparatus according to claim 1 or claim 2, wherein the habitats are tubular in configuration, and have two open ends.

5. An apparatus according to claim 3 or claim 4, wherein the habitats are circular in cross-section.

6. An apparatus according to claim 3 or claim 4, wherein the habitats are polygonal in cross-section.

7. An apparatus according to claim 6 wherein the

habitats are rectangular in cross-section.

8. An apparatus according to any of claims 3 to 7, wherein the tubular habitats are formed by a pair of spaced parallel plates between which extend a number of parallel dividing walls.

9. An apparatus according to any of claims 3 to 7, wherein the tubular habitats are sections of tubular material.

10. An apparatus according to claim 9, wherein the habitats are tubes of plastics material or rubber.

11. An apparatus according to any of claims 3 to 10, wherein the tubular habitats are formed from transparent or translucent material.

12. An apparatus according to any of claims 3 to 9, wherein the habitats are tubular metal structures.

13. An apparatus according to any of claims 3 to 12, wherein the tubular habitats are arranged horizontally.

14. An apparatus according to any preceding claim, wherein the habitats have smooth interior walls.

15. An apparatus according to any preceding claim, wherein the outlet opening of the vessel is constituted by an open upper end of a vertically-extending tube situated within the vessel.

16. An apparatus according to claim 15, wherein the tube extends vertically out of the vessel.

17. An apparatus according to claim 15, wherein the tube extends horizontally out of the vessel.

18. An installation for rearing aquatic organisms, comprising:

a supporting structure for supporting a plurality of vessels capable of containing water, the vessels arranged in a vertically extending array;

water supply means to supply water to the vessels; and

water discharge means for removing water from each of the vessels,

wherein each of the vessels has a drain opening for defining a water level within the vessel, and a number of preformed habitats within the vessel below the said water level.

19. An installation according to claim 18, wherein the water supply means supplies water to the uppermost

vessel, and the drain opening of each vessel constitutes the water discharge means, and discharges water into the next vessel below.

20. An installation according to claim 19, wherein the discharge from the lowermost vessel is treated and re-circulated to the uppermost vessel.

21. An installation according to claim 18, wherein the water supply means supplies water to each vessel, and the water discharge means removes water from each vessel independently of the other vessels.

22. An installation according to any of claims 18 to 21, wherein the vessels are open-topped trays.

23. An installation according to any of claims 18 to 22, wherein the habitats are formed by a pair of spaced parallel plates between which extend a number of parallel dividing walls.

24. An installation according to any of claims 18 to 22, wherein the habitats are sections of tubular material.

25. An installation according to any of claims 18 to 24, wherein the habitats are transparent or translucent.

26. An installation according to any of claims 23 to 25 wherein the habitats extend horizontally.

27. An installation according to any of claims 18 to 25, wherein the habitats have smooth interior walls.

28. A method of rearing aquatic organisms from a juvenile stage to maturity, comprising providing an installation according to any of claims 18 to 27, introducing into each vessel a number of aquatic organisms equal to or less than the number of habitats in the vessel, maintaining a level of water in each vessel to submerge the habitats, providing a supply of nutrients for the organisms, and maintaining water quality by regularly changing the water in the vessels.

29. A method of collecting aquatic organisms, comprising the steps of:

providing a preformed habitat for the organism wherein the habitat comprises a living chamber and an entry and exit opening;

submerging the habitat in a vessel containing water to a predetermined level;

providing nutrients for the organism;

orienting the habitat so as to place its entry and exit opening lowermost; and

placing a receptacle beneath the habitat to catch

the organism.

30. A method according to claim 30, wherein the habitat is lifted out of the water prior to the orienting step.

31. A method of collecting aquatic organisms, comprising the steps of:

providing a preformed habitat for the organism wherein the habitat comprises a living chamber, an entry and exit opening, and a further opening;

submerging the habitat in a vessel containing water to a predetermined level;

providing nutrients for the organism; and

directing a flow of water into the further opening to flush the organism out of the living chamber through the entry and exit opening; and

placing a receptacle adjacent the entry and exit opening to catch the organism flushed therethrough.

32. A method according to claim 31, wherein the habitat is lifted out of the water prior to the flushing step.

33. An apparatus substantially as herein described, with reference to figure 1, figure 2 or figure 3 of the accompanying drawings.

34. An installation substantially as herein described,

with reference to figure 2 or figure 3 of the accompanying drawings.

35. A method of rearing aquatic organisms, substantially as herein described.

36. A method of collecting aquatic organisms, substantially as herein described.

The Patent Office

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Application No:	GB 9911087.6	**Examiner:**	Paul Jenkins
Claims searched:	1-36	**Date of search:**	12 August 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): A1A (A9); A1M (MFA, MFH)

Int Cl (Ed.6): A01K 61/00, 67/00

Other: Online: WPI, EPODOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 1335572	(OCEAN PROTEIN) Whole document relevant, see especially page 5 lines 15-20 and lines 44-52.	1-14 & 29-32 at least
Y	EP 0285457 A1	(BROOKE) All figures.	15-20, 22-27
X,Y	EP 0003885 A2	(BRINKWORTH) Whole document especially page 8 lines 8-10.	X: 1-2, 6-8 & 29-32 at least Y: 23
X,Y	US 4475480	(BODKER) Whole document especially figures 1 & 2.	X: 1-5, 9-14 Y: 15-20, 22 & 24-27
X	US 4212268	(CHAPMAN) Whole document especially figures 1 and 3	1-3, 5-6, 9-15 & 29-32 at least
X	SU 1158131 A	(MARKOVSKII) See figure and WPI abstract	1-5 & 9-11 at least

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.